Fire Blight Incidence on *Malus sieversii* Grown in New York and Minnesota

P.L. Forsline
United States Department of Agriculture
Agricultural Research Service
Plant Genetic Resources Unit
Cornell University,
Geneva, NY 14456
USA

J.J. Luby
Department of Horticultural Science
University of Minnesota
St. Paul, MN 55108
USA

H.S. Aldwinckle
Department of Plant Pathology
Cornell University
Geneva, NY 14456
USA

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Abstract

***Malus sieversii* (Lebed.), a wild apple species native to Central Asia, has been recognized as the major progenitor of the domestic apple. This investigation summarizes the natural infection by *Erwinia amylovora* (fire blight) on 2590 *M. sieversii* seedlings grown as own-rooted trees. At a USDA orchard in Geneva, New York (NY), 1180 seedlings (106 populations) representing germplasm from eight sites in Kazakhstan were planted in 1997 and 1998. At a University of Minnesota (MN) orchard in Excelsior, MN, 1410 seedlings representing 124 populations from two climatically diverse sites in Kazakhstan were planted in 1998. Individuals in each population are half-sibs of each other from seeds collected from the same mother tree of wild *M. sieversii*. One of the Kazakh sites (site 9) selected for the MN trial was a mesic site at 47° N latitude chosen for its potential for extreme cold hardiness. The other group was collected from site 6, a relatively warm, xeric site. To compare results, 32 of the populations grown in MN were also grown in NY including 10 from site 6 and 22 from site 9. Natural infection by fire blight was recorded annually using a 5-point scale (1= no infection to 5= very severe). This rating was cumulative over years. In both MN and NY, we observed a 20% greater incidence of fire blight in the trees from Kazakh site 9 than from site 6, with many infected trees dying outright. Populations grown only in NY from the other six Kazakh sites had results similar to those from site 6. Where infection was medium to severe (3–5 rating), we defined seedlings as susceptible. We determined that 535 (45%) of the seedlings grown in NY were rated 1 or 2 and potentially resistant. To determine if these genotypes were truly resistant, scions from the field trees were grafted to seedling rootstock, and shoot tips of the resulting grafted plants were inoculated in a greenhouse. Of 289 of the genotypes checked to date, nearly 60% of this group that escaped infection in the orchard were resistant.**

INTRODUCTION

Malus sieversii (Lebed.) could be a valuable genetic resource for the domesticated apple potentially containing more genetic diversity for important horticultural and environmental adaptation traits. *M. sieversii* is diverse with the wild trees bearing a full range of forms, colors and tastes (Djangaliev et al., 2003). With four collection trips to Central Asia since 1989 (Forsline et al., 2003), we have confirmed that *M. sieversii* is very diverse and has all the qualities present in *M.* ×*domestica*. Wild apple seeds of *Malus sieversii* that were collected in 1995 and 1996 in sites in Kazakhstan (Fig. 1) were germinated and seedlings were grown in orchards at the University of Minnesota and at the USDA, ARS Plant Genetic Resources Unit (PGRU) at Cornell University in Geneva, New York. The objective of these plantings was to determine genetic traits of populations and individual seedlings through systematic evaluation using morphological descriptors. This discussion highlights the level of natural fire blight infection that was observed in these plantings. Preliminary results assessing fire blight resistance in *M. sieversii* seedlings grown at PGRU were reported previously (Momol et al., 1999; Luby et al., 2001, 2002; Forsline and Aldwinckle, 2002, 2004). During the period of the grow-outs, natural fire blight infection was quite heavy in most of the years between 1997 and 2006 with some very severe epidemics at both sites in the earlier years when many of the young seedlings died as a result. Absence of natural fire blight infection does not necessarily indicate resistance; however, resistance has been confirmed for some of the NY-grown seedlings that exhibit low natural levels of infection by inoculating grafted individuals under green house conditions.

MATERIALS AND METHODS

Seedlings grown in New York were planted in a double row system. Those from site 6 and 9 (Fig. 1) in rows 1–10 (600 total) were planted in 1997. Those from sites 3, 4, 5, 10, 11 and 12 in rows 11–20 (589 total) were planted in 1998. Seedlings grown in Minnesota (sites 6 and 9 only – 1410 total) were planted in a single row system in 1998 with each population replicated as four tree plots in up to four randomized blocks as tree numbers permitted. A total of 32 common populations grown in Minnesota and New York from Kazakh sites 6 and 9 are compared. Results of other populations from Kazakh sites 6 and 9 are also presented. Preliminary results for seedlings from Kazakh sites 4, 5, 10, 11 and 12 (grown only in New York) are also presented. The method for quantifying fire blight in New York is presented in Table 1. These ratings are based on 'worst case scenario' ratings in any given year, i.e., those with a rating of '1' never had evidence of fire blight. All data are presented in only 2 categories (1–2 and $\geq$3). In Minnesota, a similar scale from 1–9 was used in rating severity (Luby et al., 2002). All trees that died were rated highest ('5' in New York and '9' in Minnesota). In New York, we have begun the process of grafting scions from all seedlings that have a rating of 1 or 2 to common apple seedling rootstock and forcing these in the greenhouse followed by inoculation with *Erwinia amylovora* strain Ea273. Plants with <30% of the shoot blighted were characterized as resistant. Each grafted tree (2 for each genotype tested) is rated for fire blight resistance one time, pruned below the infected lesion, allowed to regrow and inoculated a second time. Therefore, we are making four separate inoculations (replications) for each of the grafted seedlings to determine resistance.

RESULTS AND DISCUSSION

Comparison of Fire Blight Ratings from Kazakh Sites 6 and 9 Grown in New York and Minnesota

We had the opportunity to compare the level of natural fire blight infection expressed in 32 common populations at both grow-out sites (Table 2). Ten of the common populations originated from Kazakh site 6 and 22 from Kazakh site 9. Similar low levels of minimal fire blight infection were noted in each of the grow-out sites. Seedlings from Kazakh site 6 expressed a greater potential fire blight resistance than those from Kazakh site 9. Listed are six populations from each site that had the greatest levels of potential resistance. Again we see higher levels of potential resistance in populations from the xeric Kazakh site 6.

The grow-out in Minnesota had a large number of populations that were not grown in New York (Table 3). The same conclusion is reached that the seedlings originating from Kazakh site 6 had greater potential resistance than those from Kazakh site 9.

Fire Blight Ratings for Seedlings from All Kazakh Sites Grown Only in New York

In the grow-out of all Kazakh seedlings we have observed that seedlings that originated from Kazakh site 9 had the greatest level of fire blight susceptibility (Fig. 2). Only 30% of those seedlings had potential resistance based on fire blight ratings of 1 and 2. However, >50% of seedlings from all other Kazakh sites were potentially resistant. A total of 46% of all seedlings grown in New York had potential resistance to fire blight.

Therefore, 545 seedlings of the total of 1180 were rated 1 or 2 (Fig. 2). In the project to determine if these are resistant by inoculating grafted seedlings in the green house, 470 of the seedlings have 1–4 inoculation replicates completed; 209 of those have 'resistant' reactions (<30% of each shoot affected). We will determine resistant seedlings when all replicates are completed.

CONCLUSION

Our main conclusion from this study is that observations of natural fire blight infection are effective in determining susceptible germplasm lines. Similar results over a 10-yr period in the two sites have helped determine a strategy to identify resistant lines by following assessment of natural infection with inoculation procedures. We have some encouraging preliminary results in assessing resistance. This study will continue and be used to help select superior seedlings to maintain in the main collection at PGRU. The collection at MN has been removed after 9 years of observation. Based on additional factors such as horticultural quality and potential fire blight and apple scab resistance, 87 of the MN seedlings were selected and propagated on EMLA 7 rootstock for long-term maintenance at PGRU. Scions from these 87 accessions will be grafted to seedling rootstock and inoculated with *E. amylovora* to determine if they are resistant to fire blight. Selections from the NY seedlings will be made as evaluations for multiple traits continue. Digital images are uploaded to GRIN.

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Tables

Table 1. Codes for severity of natural infection of apple shoots by fire blight.

Code	Definition
1^z	Very resistant – no occurrence
2^z	Moderately resistant – only light infection
3	Intermediate – light to medium infection
4	Moderately susceptible – medium to heavy infection
5	Very susceptible – very heavy infection

^{z} After 9–11 years of field maintenance; all seedlings that have '1' and '2' readings are grafted to seedling rootstocks, grown in the green house and inoculated with *Erwinia amylovora* to determine if they are indeed resistant. Ratings in MN were on a 1–9 scale (Luby et al., 2002).

Table 2. Comparison of ratings for natural fire blight infection of 32 *M. sieversii* populations from Kazakh sites 6 and 9 grown in Minnesota and New York with low incidence of natural fire blight (ratings 1 and 2) with a selection of six specific populations representing Kazakh sites 6 and 9^z.

Accession	New York		Minnesota	
	Sdg. #/total	%	Sdg. #/total	%
Site 9 (rating 1 & 2)				
Total (22 common populations)	84/295	29	166/416	40
GMAL 3608	7/14	50	3/9	33
GMAL 3610	5/13	38	2/5	40
GMAL 3614	4/11	36	12/24	50
GMAL 3626	4/13	31	20/42	48
GMAL 3629	4/14	29	19/29	65
GMAL 3643	4/14	29	30/39	77
Site 6 (rating 1 & 2)				
Total (10 common populations)	75/104	52	138/224	62
GMAL 3682	9/12	75	15/22	68
GMAL 3685	6/15	60	5/16	31
GMAL 3687	11/14	78	13/21	62
GMAL 3688	6/15	40	23/39	59
GMAL 3689	9/17	53	30/45	67
GMAL 3690	9/15	60	25/40	63

^{z} Each of the populations represent progeny collected from a specific tree at the designated site listed in Fig. 1. Each of the seedlings are half-sibs of each other. Information on each accession can be accessed at: http://www.ars-grin.gov/npgs/

Table 3. Cumulative results for natural fire blight infection ratings for all populations representing Kazakh sites 6 and 9 grown in New York and Minnesota, many of which were not commonly grown.

	New York			Minnesota		
	populations	Sdg #/total	%	populations	Sdg #/total	%
Site 9 (rating 1 & 2)	29	101/388	26	97	425/1098	39
Site 6 (rating 1 & 2)	14	108/203	53	27	177/312	57

Figures

Fig. 1. Map of Regions in Central Asia where *Malus sieversii* (Lebed.) was collected in 1989, 1993, 1995 and 1996.

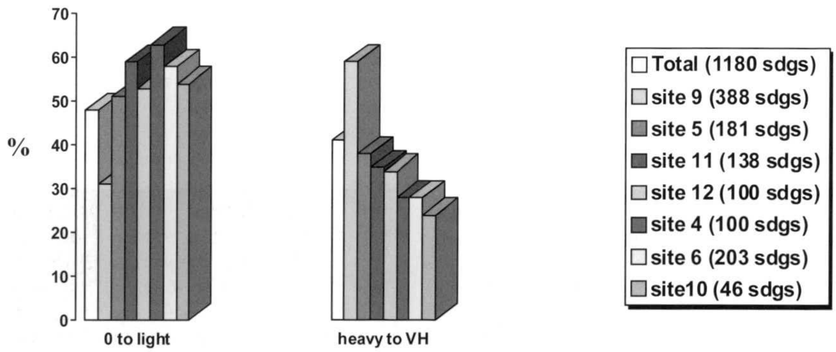

Fig. 2. Natural occurrence of fire blight in *M. sieversii* seedlings in the Geneva, NY collection from 7 different sites in Kazakhstan based on Table 1 evaluations (0 to light = ratings 1 & 2; heavy to very heavy (VH) = ratings 4–5).